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most serious one, it was readily detected by Dr. Ravn, and after calling it to the attention of others it was not at all difficult to recognize it again.

It has always been a matter of surprise to the writer that this rust has not occurred in North America before, the rust being so common in Europe and samples of wheat constantly passing back and forth. Nevertheless, its existence this season in such abundance in portions of Oregon and Washington makes it evident that either the rust has increased with remarkable rapidity or has already existed in the country for several years. The latter, if true, would be in face of the fact that it is easily distinguished from other rusts and that pathologists have been actively studying the rusts of the country. Further details of the occurrence of the rust will be reported later.

M. A. CARLETON

July 3, 1915

SCIENTIFIC BOOKS

A Study of the Orbits of Eclipsing Binaries.

By HARLOW SHAPLEY. Contributions from the Princeton University Observatory, No. 3, 1915. 4to. Pp. vii + 176.

In astronomical literature one of the most frequent subjects refers to the "orbit" of a heavenly body. In fact, for a long time a standard topic for a doctor's thesis was the determination of the definitive orbit of a comet. Here the task of the candidate was to derive from observations, made in all parts of the world, the best possible numerical values for the six elements or constants which define the path of the comet as a conic section in space with the sun at the focus. Other classes of orbits are those of visual double stars, spectroscopic binaries, and finally, as in the work under review, we have what may be called photometric orbits, since the results are based upon observations of the light variations of stars.

Even to those familiar with the subject, the amount of mathematical analysis that has been based upon the changes of some of the variable stars is a source of wonder. As an illustration may be mentioned the famous star *Algol*, which has been the subject of half

a dozen extended monographs, scores of papers and literally tens of thousands of observations. The special importance of the stars whose variations are due to the eclipses of large close companions is due to the fact that these systems give us the only satisfactory clue to the actual diameters of stellar bodies. The theory of such cases has been well understood for a long time, but recently Professor H. N. Russell, of Princeton University, has developed a new method for determining the elements of eclipsing binaries. He recognizes the fact that measures of the light of stars are seldom if ever accurate to one per cent., so that approximate and graphical methods are sufficient for any case that can arise. In essence his method consists of solving not directly for the elements of a double system, but for the best light-curve that will represent the observations, and then the characteristics of the system are easily computed from the curve. A series of papers on this general subject have appeared by Russell and Shapley, and the present contribution summarizes much of the previous work. Though not so stated, it is understood that this is a thesis for the doctor's degree, with subsequent additions to bring the work into complete form.

Whereas formerly an exhaustive study of one star was thought to be quite a piece of work, Dr. Shapley with the new methods has undertaken and carried through a pretty thorough discussion of 90 eclipsing stars, or all for which any sufficient data exist at the present time. We learn that the discussion of a single object required not less than a day, nor more than two weeks. Even though nearly all of the observational material was already available, it was a considerable task of mere routine to get it together, and one of the advantages of this memoir is that it will serve as an index to the best sources of information concerning any particular star.

There is a vast difference in the quality and completeness of the data for different systems, and many of the numerical results are avowedly only rough, or perhaps even guesses. In particular, the proportion of light which comes from the fainter component, as indicated by the secondary eclipse, has to be assumed in

the majority of cases. As practically everything else depends upon this guess, the further discussion is for many stars only an indication of what may be true. This limitation is well enough understood by the author, but there is danger that a casual reader, on seeing the array of tabular results, will infer that all of the numbers rest upon a secure observational basis.

The title of the work is something of a misnomer, as in the table of so-called orbits we find for each system, in addition to the characteristics of the light variation and relative paths of the bodies, the radius of each in terms of the distance between them; the proportion of light given by each component; their densities; constants giving the approximate shapes of the ellipsoids produced by tidal action; and finally the hypothetical dimensions and parallax of each system, based upon certain assumptions. There is omitted, however, the quantity which may be rigorously derived, namely the mean density of the system, which does not depend in any way upon an assumption as to the total mass, or how it is divided between the two bodies. Russell and Shapley were the first to take into account generally the probable darkening of stellar disks toward the limb, such as exists in the case of the sun, and throughout this work the results are given as based upon the alternative or limiting cases of apparently uniform disks, and of bodies completely dark at the apparent edge. The convenience of the description leads to such anomalous terms as a "uniform orbit" and a "darkened density."

It has been fairly well known that the fainter component of an eclipsing system is likely to be the larger, but Shapley now points out that this is due to the manner of observational selection. The most usual cases actually existing consist of systems with small faint companions, the apparent preponderance of the other type being due to the fact that large companions produce greater variation in light, and hence are more readily discovered.

Thanks to the work of the Harvard Observatory, the spectra of most of the eclipsing stars have now been classified, and one of the most interesting results comes in the relation

between spectral class and density. Shapley finds that the white stars of the Orion and Sirian type range from slightly less than the solar density to $1/100$ of this amount; but among the yellow stars, having the same spectrum and presumably the same surface conditions as the sun, there are densities ranging from three times larger than the sun's to only $1/100,000$ on the solar standard. This extreme range in eight stars needs to be supplemented by more data, but so far as it goes the evidence supports Russell's contention that there are two classes of yellow and red stars, the so-called giants and dwarfs, the latter being much more condensed than the former.

The use of hypothetical parallaxes may not appeal to some students of exact science, but, after all, the assumption that a double system has twice the sun's mass, combined with a reasonable estimate of the surface intensity of a star with known spectrum, gives valuable information. Most of these eclipsing systems are at such great distances that direct measures of parallax are absolutely hopeless; and since the computed distance varies only as the cube root of the assumed mass, good estimates of probable average distance are obtained. The general inference from the eclipsing binaries confirms the conventional view that the universe of stars is more extended in the direction of the Milky Way than at right angles to that plane.

The general discussion of results covers twenty quarto pages, but a summary on a single page would have been welcome. In fact, there is some difficulty in the reader's getting all out of the work that is actually there; for instance, there is no discussion showing what is a normal or average eclipsing binary. Using Shapley's data, the reviewer finds it probable that the preponderant type of eclipsing system consists of two bodies with a distance between centers of about five times their average radius, a period of four days, and a mean density $1/20$ that of the sun.

In view of the present rate of discovery of eclipsing stars, and the prospect of many more additions from the list of spectroscopic binaries, the new methods of treating the observational data are especially welcome, and all

told the work at Princeton as illustrated by the contribution under review, marks an important advance in this department of astronomy.

JOEL STEBBINS

An Index to the Museum Boltenianum. By WILLIAM HEALEY DALL. Smithsonian Publication No. 2360. 1915. 8vo. Pp. 64.

Rarely has the credit of a great life's work approached more perilously near oblivion and still be enrescued and enshrined in proper setting, than did that of the conchologist J. F. Bolten, of Hamburg. His life was practically his collection, systematically arranged, large, beautiful. In the arrangement of his collection he followed his own system, far in advance of that proposed previously by Linnæus. An outline manuscript was prepared of this system, and some illustrations were prepared by an artist-friend, Schulze by name, but death deprived the work of the artist's aid, and Bolten's infirmities prevented the prosecution of the undertaking. The outline of the system published by the family in 1798 after Bolten's death would only have been of value to the world as showing the size of the Bolten collection had not a second friend, Roeding by name, seen to it that specific names were accompanied by references to Gmelin's "Systema" and to the figures in the Conchylien Cabinet and elsewhere. In 1819 another edition serving as a sale catalogue was published; but both editions have long ago become very scarce and well-nigh forgotten. Again, a third friend, Dr. Dall, in a distant land, united a private donation with a small grant from the American Association for the Advancement of Science and had the same turned over to Sherborn and Sykes of the British Museum (Nat. History) who brought out a phototypic copy of the edition of 1798 (1906). Now, we have before us finally an elaborate and convenient index to this edition prepared by the same thoughtful friend and published as noted above by the Smithsonian Institution. It is naturally to be regretted that funds did not permit of the publication of the index with the volume, but nevertheless there is real satisfaction in feeling that the work is now in

available form and the labors of Bolten shall not be forgotten.

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THE PROCEEDINGS OF THE NATIONAL
ACADEMY OF SCIENCES
(NUMBER 6)

THE sixth number of Volume 1 of the *Proceedings of the National Academy of Sciences* contains the following articles:

1. *Confirmatory Experiments on the Value of the Solar Constant of Radiation:* C. G. ABBOT, F. E. FOWLE and L. B. ALDRICH, Smithsonian Institution, Washington, D. C.

Observations at Mt. Wilson from sunrise until ten o'clock and records obtained by a recording pyrhelimeter attached to sounding balloons rising to the altitude of 24 km. confirm the value 1.93 calories per square centimeter per minute previously obtained for the radiant energy received by the earth from the sun.

2. *Variation of Flower Size in Nicotiana:* T. H. GOODSPEED and R. E. CLAUSEN, Department of Botany, University of California.

During five years of study of the inheritance of flower-size in *Nicotiana*, it has been found that the flower-size is not so constant as it has been assumed to be, but is affected by a number of conditions, some of which may not effect the length and the spread of the flower in the same manner.

3. *Retention in the Circulation of Dextrose in Normal and Depancreatized Animals, and the Effect of an Intravenous Injection of an Emulsion of Pancreas upon this Retention:* I. S. KLEINER and S. J. MELTZER, Department of Physiology and Pharmacology, Rockefeller Institute for Medical Research.

In normal animals the circulation possesses the ability to get rid readily of a surplus of dextrose injected intravenously. This ability is impaired in the absence of the pancreas, but can be temporarily restored by intravenous injections of pancreas emulsion. Such injections, moreover, are capable of reducing the hyperglycæmia due only to depancreatization.